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ONR QUARTERLY TECHNICAL REPORT

AGREEMENT NUMBER N00014-92-J-1308

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LEHIGH UNIVERSITY

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ONR REPORT

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Preliminary kinetics studies of SiGe oxide growth were conducted on spare samples with and without boron doping. Reasonable oxides were grown for 100 ppm additions of NF_3 to the dry O_2 ambient, as measured by ellipsometry.

The doctoral student on this project picked his doctoral committee, which includes Dr. Phillip E. Thompson from the Naval Research Laboratory. His proposal, entitled "The Low Temperature Oxidation Behavior of SiGe Thin Films in a Fluorinated Ambient" has been approved. Dr. Thompson has provided an initial set of Si-Ge-covered wafers with 2,5,10 and 20 percent Ge, prepared by MBE. Additional samples have been ordered from AT&T Bell Laboratories.

Our work on this contract has been concerned with the use of implanted germanium to reduce hot electron injection from silicon into SiO_2 in MOSFET Devices. The deleterious effects due to this injection has become a major problem associated with ultra small devices now being developed for use in contemporary technology. We were intrigued by the earlier publication of Ng et al.[1] indicating that germanium would reduce this effect without causing a degradation of the operating device characteristics. Our work has certainly confirmed their conclusions.

Most of our work has been concerned with simple MOS structures. We have used our avalanche injection apparatus to make the measurements. Our standard practice is to implant a portion of a wafer with the germanium and use the rest of the wafer as a control for comparison purposes. We universally observe that the germanium even in small implant dosages (down to $10^{12}/cm^2$) increases the avalanche voltage required to obtain a given current through the oxide. For a given voltage the injection current can be reduced by orders of magnitude. This is supported by Figure 1.

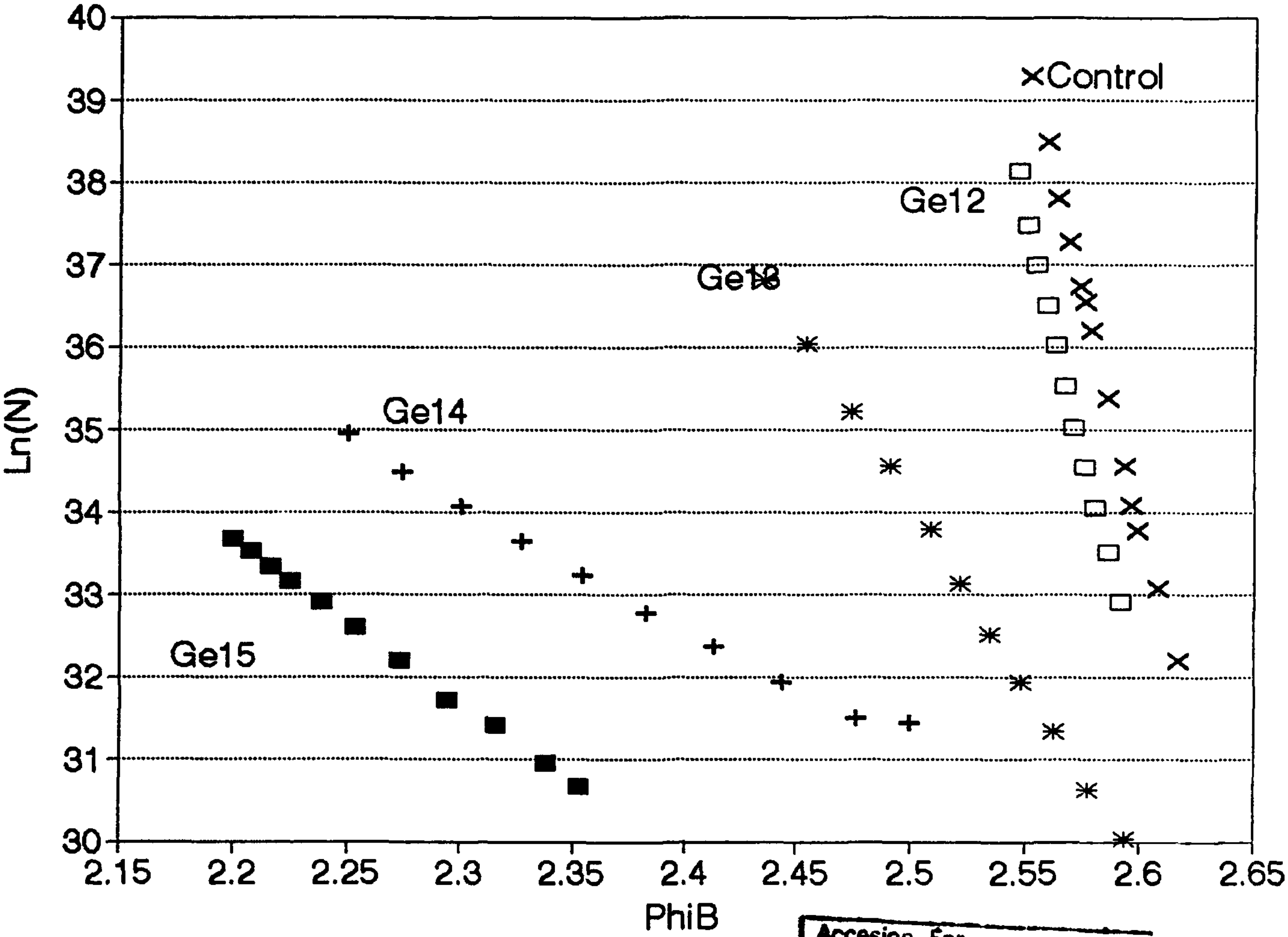
As the implant dosage increases there are two undesirable ffects. Since some of the germanium is located in the oxide the electron trapping rate increases and also the germanium located at the interface results in an increase in the interface state density. With these detrimental effects we would recommend that the applied dosage be less than $10^{14}/cm^2$. From the data presented it can be seen that dosages of $10^{13}/cm^2$ still result in a very significant reduction in the injected current.

By implanting before the oxide is grown we eliminate the oxide traps due to germanium since under these conditions the germanium does not go into the oxide. However, we observe that the reduction in hot electron injection is reduced. One possible reason for this might be that the germanium ends up at the interface and not in the bulk of the silicon. We are exploring this further.

Using the theory we have developed earlier for avalanche injection using the saw tooth wave form, we have been able to calculate the energy distribution of the hot carriers in the silicon over the energy range controlled by the barrier lowering effect. These results also dramatically demonstrate the reduction due to the germanium.

In summary, these results clearly demonstrate the beneficial results that can result from germanium implantation and we are convinced that this should be given serious consideration for use in contemporary technology. Our work continues on the optimization of the process to be used to obtain the best results without serious side effects.

1) "Suppression of Hot-Carrier Degradation in Si MOSFET's by Germanium Doping," Ng et al., Electron Device Letters 11, 45 (1990).



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